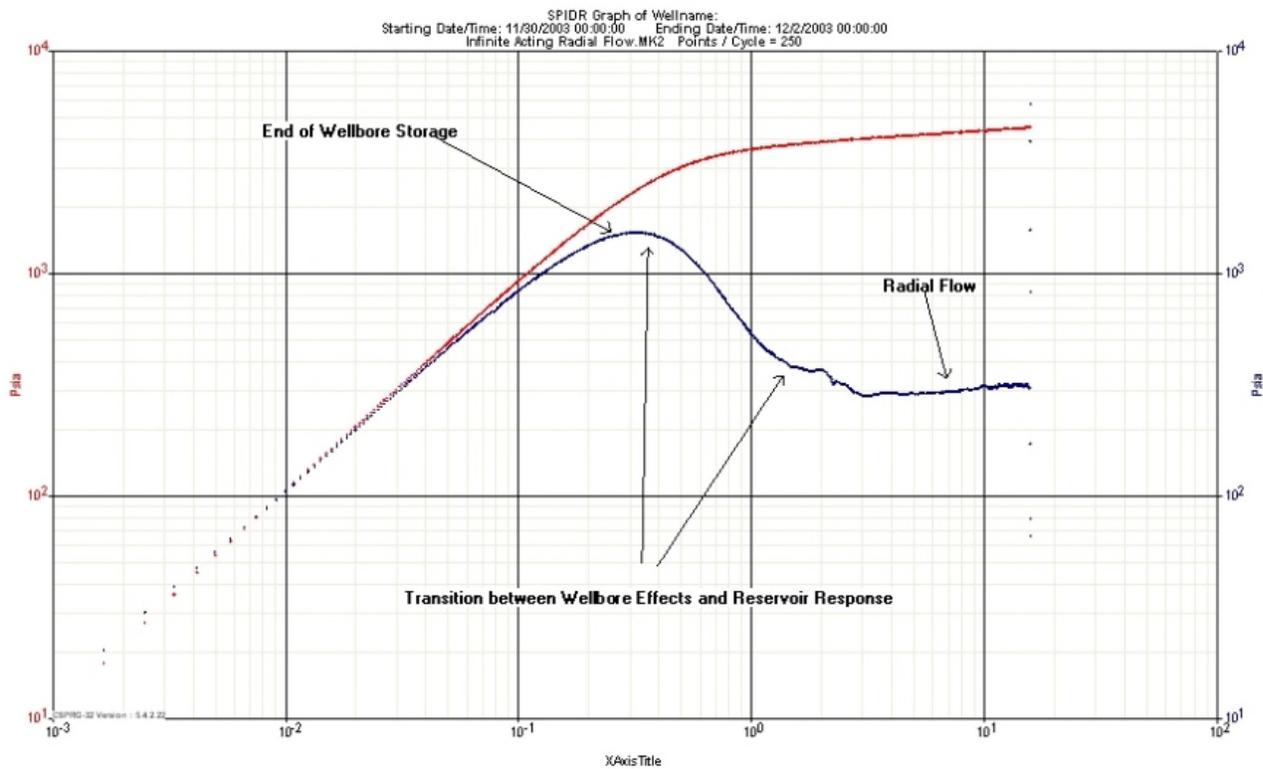


The Effect of Wellbore Storage on Surface Data

Engineers often ask how much of an effect wellbore storage has on surface data for a pressure-transient test. Wellbore storage is afterflow of fluids into the well bore after the well is shut-in at the wellhead. During wellbore storage, reservoir effects are masked or distorted, making it impossible to quantify well properties such as permeability, skin and P^* . Wellbore storage effects last until pressure is equalized between the well bore and formation. The duration of wellbore storage is primarily dependent on three factors: the wellbore volume, the formation permeability and the fluid compressibility. Larger volumes, lower permeabilities and larger compressibilities (gas wells) increase the duration of wellbore storage. In most circumstances masking due to wellbore storage effects ends after the early-time "hump" on a pressure derivative plot. Figure 1 illustrates this behavior:



One of Halliburton's customers recently had specific concerns because his wells had particularly large wellbore volumes. The wells were in excess of 14,000 ft. deep and were flowing up 7" casing. Since these were gas wells, the duration for wellbore storage could be significant and could potentially mask reservoir response. An examination of our test library pointed to a couple of wells that Halliburton had tested with very similar wellbore and fluid properties, but differing permeabilities (~25 md vs ~125 md). In the 25 md well wellbore storage ended after about one hour and began to enter radial flow. At this time, the radius of investigation was 200ft. In the 125 md well, wellbore storage effects were finished much more quickly, in a matter of minutes. For this well, the radius of investigation was 50-150 ft. depending upon what one considers the end of wellbore storage.

Four salient points arose out of this discussion:

1. Any potential reservoir effects (e.g. a near wellbore limit) nearer to the wellbore than the R_i 's listed above will be masked by storage effects.

2. This masking occurs regardless of gauge placement. A surface gauge or bottomhole gauge would experience these same storage/masking effects for about the same length of time.
3. The wellbore volume, formation permeability and fluid compressibility are all independent of gauge placement.
4. The only way to avoid wellbore storage effects is to shut-in the well as close to the reservoir as possible using a downhole shut-in tool.

By running a downhole shut-in tool or when testing below a closed ball valve on a DST string you are dramatically decreasing wellbore volume and thus dramatically reducing the potential effects of wellbore storage on low permeability formations.

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